VIII. AGRICULTURE

Introduction

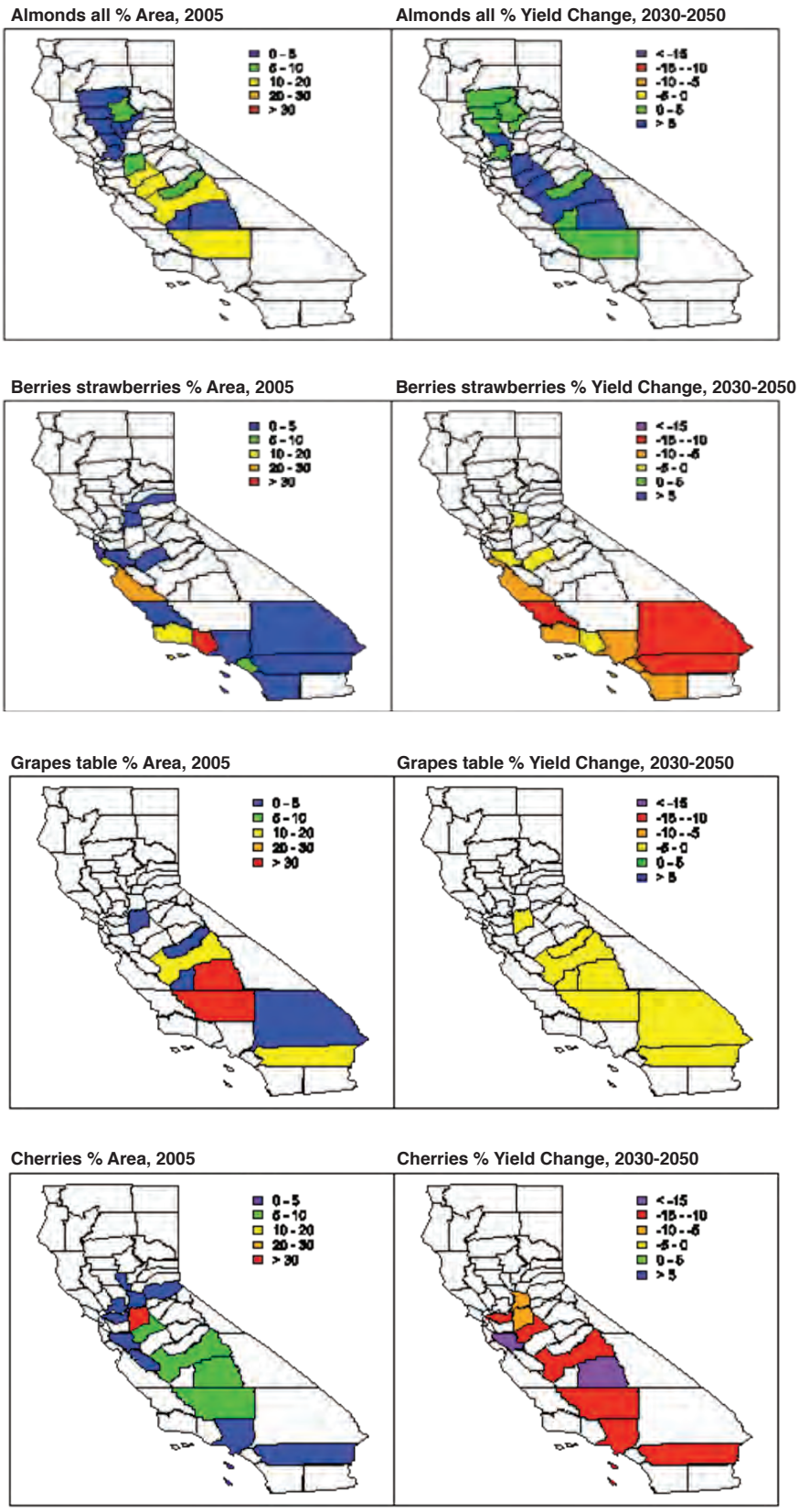
"Conservation is ethically sound. It is rooted in our love of the land, our respect for the rights of others, and our devotion to the rule of law." -Lyndon Baines Johnson

California has been the most productive agricultural state in the union for more than 50 years.[1] From 1974 to 2004, the value of California's agricultural commodity gross cash receipts more than quadrupled while the total acreage devoted to agriculture declined by 15 percent. This growth in production gross sales value is due largely to technological improvements in crop production and more intensive use of farmland, including the shift to higher value crops. Today, with tens of thousands of family farms and ranches, California agriculture produces more than $37 billion in farm gate revenue.[2] California has become the nation's leading producer of nearly 80 different crop and livestock commodities. In fact, the state supplies more than half of all domestic fruit and vegetables and is responsible for more than 90 percent of the nation's production of almonds, apricots, raisin grapes, olives, pistachios and walnuts.

The diversity and size of California's agricultural sector creates unique opportunities and challenges with regard to climate change. Climate change alters both average and extreme temperatures and precipitation patterns, which in turn influence crop yields, pest and weed ranges and introduction, and the length of the growing season. Extreme events, such as heat waves, floods, and droughts, may be among the most challenging impacts of climate change for agriculture since they can lead to large losses in crop yields and livestock productivity. Since California plays a critical role in feeding not only state residents, but those of the U.S. and other countries, these large production declines and losses would translate to not only food shortages but financial and economic shifts that could disrupt local, regional, and national commodities systems. In the Delta region, saltwater intrusion from sea level rise may make production of certain crops increasingly challenging. Traditional water delivery systems may face challenges due to generally drier conditions and the reduction of the Sierra snowpack concurrent with urban demand increases.

Understanding the implications of climate change on the agricultural sector and the world's food supply not only underscores the importance of California's leadership in reducing GHG emissions, but can also provide invaluable guidance to growers and policymakers on how to prepare for and adapt to changes that may occur.

Figure 16: *California perennial crops in a changing climate*



Current % of crop area in each county (left) and average projected changes in county yields (right) for four perennial crops. Yield changes are expressed as percentage difference between average yields in 2030–2050 and those in 1995–2005

Future Climate Change Impacts to Agriculture

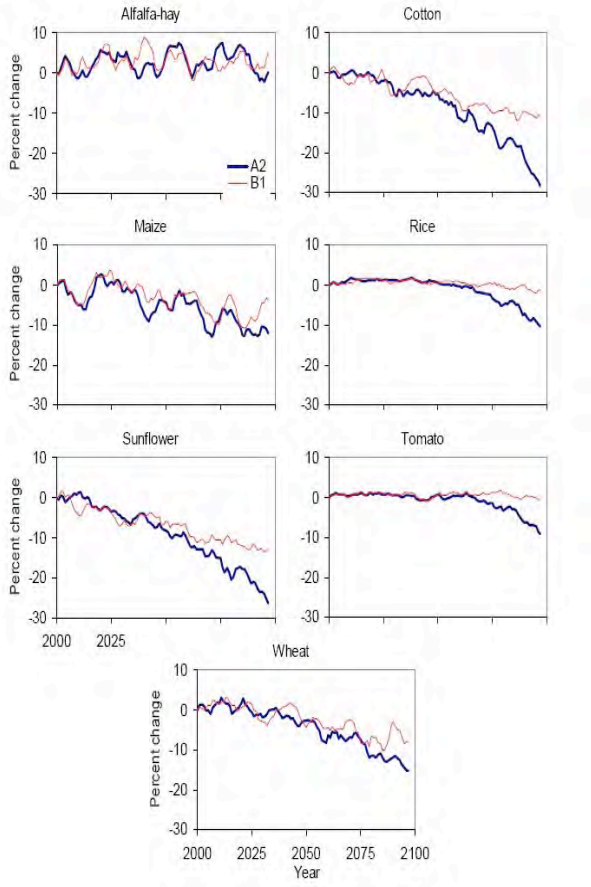
A. Increased Temperature and Extreme Events

California's agriculture could be severely affected by the warming projected by the latest climate change models.[3] Some crop yields may increase with warming, while others may decrease. According to these models, many of today's top annual field crops such as wheat, cotton, maize, sunflower, and rice show declining yields later in the century due to rising temperatures (see Figure 17).[4]

Conversely, the production of high-quality wine grapes is expected to benefit from a warmer climate because of a longer growing season and more favorable growing conditions in the short-term. At some point, however, the magnitude of the warming may become too large for certain grape varieties.

Agriculture may benefit from higher levels of atmospheric CO_2 (which functions as a fertilizer and increases the efficiency of the plants' water use) as well as from the lengthening of the growing season as freezing temperatures may become less common over the course of the 21st century. Yet these temperature changes not only affect desirable crops, but also undesirable pests. Weeds and other invasive species are likely to migrate north due to temperature increases, while disease and pest pressures will increase with earlier spring arrival and warmer winters. In addition, crop-pollinator timing can also be affected by climate change, leading to a need for modifications in crop production.

Figure 17: *Modeled crop yields by 2100, shown in 25-year increments (2000, 2025, 2050, 2075, 2100)*



PREDICTED AGRICULTURAL IMPACTS OF WARMING

- Crop Yield Changes
- Changes in Crop Types and Cultivars
- New Weed Invasions/Expanded Ranges of Existing Weeds
- New Disease & Pest Invasions/Expanded Ranges of Existing Diseases & Pests
- Flooding and Crop Pollination Changes
- Heat Waves and Stress
  - Loss of Crop Quality and Yields
  - Increased Vulnerability to Pests
  - Increased Animal Vulnerability to Disease
  - Increased Mortality of Animals
  - Less Production from Animals

Higher average temperatures can cause increases in mortality and/or decreases in productivity of livestock, leading to decreases in meat, egg, and dairy production and reproductive success of cattle.[5] Greater proliferation and survival of pathogens and pests will affect both crops and livestock.[6]

Temperature and precipitation changes can also disrupt the critical link between agriculture and biodiversity. In California a large number of wildlife species are dependent on privately owned agricultural lands for habitat and a reliable food source. As temperature and precipitation patterns change it is likely that there will be a shift in the intensity and location of agriculture that could impact fish and wildlife resources. Agricultural lands can provide significant habitat and connectivity between protected reserves, but can also compete with fish and wildlife for resources that may become limited due to climate change. Predictions of higher proportion of precipitation in the form of rain with concomitant loss of snow pack suggests more frequent summer droughts, thereby creating conflicts between beneficial uses of water. Further impact to fish and wildlife may result from the management of pests and pathogens that may proliferate within agricultural settings with warming temperatures.

Reduction of Chill Hours

While many crops benefit from the increase in average temperatures and the lengthening of the growing season, not all do. Some of California's most valuable crops, such as fruits, wine grapes, and nuts, require a certain number of chill hours in the winter. Chill hours are the number of hours below a certain temperature that a plant requires for dormancy before springtime growth. The temperature threshold and duration of dormancy needed are species-dependent, yet without the required period in dormancy, blooming, the setting of fruit, fruit quality, and therefore crop yields are negatively affected.[7]

The number of winter chill hours has already declined since 1950 with the greatest rates of change occurring in the Bay Delta region and the mid-Sacramento Valley. Grapes and almonds, which are grown in these regions, may need to be replaced with new cultivars that require fewer chill hours or alternative crops that do not require as many winter chill hours in order to avoid substantial losses.

For many high-value crops, a reduction of chill hours could be harmful. In one study, researchers examined the effects of climate change on the 20 most valuable perennial crops grown in California. They found that cherries, the 18th most valuable perennial crop in the state, are likely to be the most negatively affected by warming in coming decades. This finding is likely related to a loss of chilling hours. A second robust finding of the study was that almonds, the most valuable perennial crop in California and the source of the world's supply, will be harmed by increasing February temperatures. None of the crops studied showed any clear benefits from projected warming.[8]

Changing Temperature Extremes

Understanding how climate change affects the occurrence of temperature extremes is crucial for California's agriculture. The costliest acute event to California's agriculture in recent years was the freeze of December 1998. Various crops, including oranges, lemons, olives and cotton, experienced major losses. The second costliest individual event was the heat wave of July 2006, which was especially damaging to the livestock industry.[9]

In recent decades, cold extremes have already become less frequent, and are projected to become even less frequent across the state in the future.[10] Heat waves, by contrast, are very likely to become more frequent due to climate change.[11,12] Climate scenarios using the higher emissions scenario suggest that heat waves similar in length and intensity to the one experienced in July 2006 may become as frequent as once a year in many parts of California by the end of the century.[13]

The heat stress caused by extremely high temperatures can increase livestock vulnerability to disease, infection, and mortality; and can decrease livestock production. For crops, heat stress can lead to losses in quality and yields; and can increase plant vulnerability to pests. Extreme heat can also indirectly affect irrigated agriculture by generating short-term disruptions of the water supply, as well as increased water needs due to higher rates of water loss from evapotranspiration.[14]

B. Precipitation Changes and Extreme Events

Most climate change projections show a general drying trend over California, resulting in reduced water deliveries from a decreasing Sierra Nevada snowpack. This would lead to a water supply and supply reliability risk for agriculture, with more competition among all water users. A decrease in water supply reliability will direct crop selection to crops, such as row/field crops, that are not dependent on a steady long-term supply of water. Also, with less reliability, comes greater risk, which affects the availability of operating credit from lending institutions. One study found that under any projected climate scenario, agriculture would consistently be most vulnerable to water shortages. Researchers also estimated that annual costs of approximately $200 million would be incurred by agriculture if water availability was more than 20 percent lower than demand. [15]

Droughts and legal constraints on water delivery have in some years led to losses in excess of $1 billion annually to Central Valley agriculture, translating to tens of thousands of lost jobs, and a reduction in world food supply. Thus, short of significant adaptations, water supply reductions and intermittent disruptions will adversely affect agricultural crop yields. One modeling study combining future crop yield predictions with future water supply stresses indicated notable declines in overall crop acreage and production by 2050.[16] This potential scenario is of particular concern because of the protected demand on food supply attributable to population growth world wide.

Non-irrigated lands, despite their lack of dependence on water delivery systems, can also be impacted by altered precipitation patterns. For example, low or infrequent rainfall results in less forage on California rangelands, which can result in lower livestock productivity and increased soil erosion and water quality degradation.

Agricultural impacts can differ geographically under Delta water system shortages. For example, water shortages may be more acutely felt in the western San Joaquin Valley and Tulare Basin.[17] With projected climate change the San Joaquin Valley is projected to have potentially greater irrigation demand and evapotranspiration than the Sacramento Valley, leading to more risk for agriculture in the southern Central Valley counties by the end of the century.[18] Some of these shortages may be managed by changes in technology and agricultural practices. For example, if additional water conservation measures and new technology becomes available in the next few decades in San Diego County, agricultural demand for water could actually decrease, shrinking from 13 percent of total county demand in 2005 to six percent in 2030.[19] However, the prospects of achieving this level of efficiency increases without a reduction in acres or crop yields are improbable especially in light of the very high level of water efficiency that is currently being employed in other parts of the state.

AGRICULTURE- PREDICTED IMPACTS OF PRECIPITATION HANGES

- Loss of Water Supply and Reliability
- Loss of Food Security as Water Supply Diminishes, is Less Reliable
- Loss of Irrigated Lands, Crop Production and Food Security
- Lack of Water for Agriculture and Livestock
- Drier Conditions May Affect Agricultural Crop Yields
- Increased Fire Risk to Rangeland
- Dry Steep Terrain - Increased soil erosion and sedimentation from Agricultural Lands
- Changes in Pests, Diseases and Invasive Species
- Changes in ozone and air quality - likely adverse affects on crop production

Drought can produce severe lack of water for crops and livestock, increase the risk of fire on rangeland, and ultimately reduce food security. Historically, irrigation has helped to minimize the impact of droughts, but climate projections suggest that long-lasting droughts may become more common under the higher emissions scenario later in the 21st century. Such severe decreases in water availability may well limit the types and amounts of crops grown in California.[20]

The ultimate impact of changing water supplies will depend on the degree to which farmers switch to crops and livestock that are better adapted to the new climate conditions as well as to potentially lower water supplies, market value changes in crops and livestock, and usage of water efficiency and conservation measures. According to DWR, most new water that derives from conservation will come from urban water use efficiency; most readily-adopted agricultural water conservation measures have already been implemented.[21] The gains in water use efficiency by agriculture over the past forty years was documented in a recent preliminary draft paper, which documented a doubling in inflation-adjusted dollars of agricultural gross revenue between 1967 and 2007, while during the same period total crop applied water fell by 14 percent.[22]

AGRICULTURE
IMPACTS OF SEA LEVEL RISE

- Saltwater Intrusion onto Coastal Farmland Soils
- Seawater Flooding of Low-lying Farmland
- Increases in Soil, Surface Water, and Ground Water Salinity
- Increased Upstream Flooding

Heavy Rainfall and Flooding Events

The agricultural sector is also challenged in wet conditions. For example, some farmlands in or near floodplains could be inundated when winter and spring rainfall combine with rapid snow melt (due to higher temperatures over the Sierras) and generate larger runoff than streams and soils can absorb.[23]

Flooding during the planting season is known to be particularly damaging for crops. A study of the impacts of extreme events on California agriculture, using disaster and insurance loss data over the years 1993-2007, showed that excess moisture related to heavy rainfall events and subsequent flooding led to the greatest overall economic losses during these years.[24] Specifically, heavy rainfall in the spring and winter months accounted for the 3rd, 4th and 5th costliest individual extreme events. While the number of storms is not expected to increase in the future, heavy rainfall events will continue to play a significant role in California's future climate. Especially in the Delta region, increases in winter flooding can be expected due to the coincidence of rainfall events and earlier runoff with higher sea levels. This may necessitate additional levee maintenance to protect farmland.

C. Sea Level Rise

Sea level rise impacts include saltwater intrusion onto farmlands and an increased risk of coastal flooding of low-land agriculture. Both will raise soil salinity to a point which most crops currently grown are not adapted. Increases in surface and groundwater salinity, as well as decreases in irrigation water quality near the coast, will negatively impact coastal agriculture.

Sea level rise impacts may also constrain farmers' abilities to adapt to changing water supplies and temperatures as some management practices, irrigation methods, and crop switching may not be possible in areas near sea level increases. Livestock operations and croplands may need to be relocated onto more productive lands. Investments in technology, plant breeding and cropping system research will help minimize some of the projected climate change-related agricultural impacts.[25]

D. Risks for Agriculture

To summarize the changing risks that California's agricultural sector may be facing from climate change, the likelihood of occurrence of the projected consequences was qualitatively assessed. The emerging risk profile for the agricultural sector can be characterized as follows:

- Climate change is likely to alter:
    - Precipitation amounts and patterns
    - Average as well as maximums and minimum temperatures, resulting in growing season lengthening and chilling hours reductions
    - Pest and weed ranges

  The resulting critical changes in water availability, temperatures, sea level rise and extreme events will all affect crop and livestock productivity which in turn will have a direct impact on domestic and international food supply.
- Extreme events may be among the greatest challenges, as they can lead to large losses of crops, impose stress on livestock, and be most difficult to manage.
- Perennial crops such as grapes, fruits, and nuts will experience varying risks, with moderate warming potentially benefiting some crops such as table grapes and almonds, but mostly negatively impacting other perennial crops, such as cherries.
- Yields of some annual crops such as cotton, maize, sunflower, and wheat are expected to slightly decrease by mid-century, while rice and tomato yields remain more or less unchanged. By the end of the century there is a growing risk of declining yields of all examined crops except alfalfa; that risk is significantly higher under the higher emissions scenario.
- Livestock is particularly at risk from heat extremes, which can lead to increased risk of mortality, lower productivity, and lower reproductive success.
- Sea level rise and increased winter run-off together with meltwater will increase low-land flooding risks. Sea level rise together with higher moisture loss from soil and water table drawdown will increase the risk of high salinity in coastal soils, thereby negatively impacting salt-sensitive crops.
- Disruptions in temperature and precipitation patterns can disrupt the link between agriculture and biodiversity.
- Hydrologic changes will decrease agricultural water supply reliability and thus diminish food security.
- Hydrologic changes will increase both threat and risk of crop and soil damaging flood on agricultural lands.

Agriculture Adaptation Strategies

Introduction

The state agencies that participated in the Climate Adaptation Working Groups (California Department of Food and Agriculture and California Department of Conservation) developed the following strategies and shall be responsible for and will spearhead strategy implementation. California's family farms and ranches play a large role in the state's economy, and rural culture; as a result, climate change will have countless impacts on the cultivation of crops and livestock. In addition, California agricultural productivity is of strategic importance to the state and nation, as a major producer of the nation's food supply. California's family farms and ranches have been successful in large part due to their ingenuity and capacity to adapt from year to year and over the long haul to changing growing conditions, such as pests and disease, labor availability, weather and market demands. To adapt to changes in temperature and precipitation, a number of approaches are proposed or in development to assist in increasing the diversity of California's agricultural commodities, thereby fostering resilience within the industry. The identification and development of crops and animals found to be resistant or better suited to the myriad of climate change variables is central when planning for adaptation and will ultimately support California farmers and preserve their ongoing operations.

Local Government Example:

Yolo County is completing the update of its general plan. The update places a strong emphasis on responding to climate change, including policies to help agriculture adapt. Among the policies are those that aim to keep as much agricultural land free from the constraints of urbanization, thus broadening the landscape flexibility for adaptation; protect water supplies through such measures as protecting groundwater recharge basins and supporting improvements in water use efficiencies; assist farmers to anticipate and respond to opportunities and adversities resulting from climate change; promote practices that sequester carbon long-term to help growers qualify for carbon credits; support the production and use of agricultural bio-fuels for economic sustainability; and, promote local market outlets to reduce transportation energy costs.

Increased research into development of crops or cultivars which exhibit an increased tolerance to heat waves, high average temperatures, drought, pests and disease should be encouraged. Strategies are also being developed that support the research of crop rotations that maximize efficient water usage. Continued improvements in irrigation systems will further the reliability of water supplies through water conservation. Management practices that address adaptive flood control will also serve to benefit existing levees and adjacent floodplains; while incentives will allow for the cultivation of floodplain compatible crops introduced in the areas prone to regular flooding.

To protect against agricultural weeds, pests and diseases, additional investments should be made in the detection, prevention and eradication of invasive species that originate from outside of the state or have relocated from other regions within the state. Further research is needed in the development of best management practices that enable adaptation, or can help predict and respond to the spreading of weeds, pests, and disease. Resilience to harmful pests and associated diseases may be optimized by providing growers with the most favorable management techniques possible, ones that will harmonize with planting, thinning, and harvest timing.

In concert with adaptation, mitigation protocols favor low carbon emission strategies such as renewable energy production on farms, and the development of a carbon and carbon equivalent credit mechanism that can be utilized in concert with food and fiber production in the future. Research is also needed to develop low-carbon, non-petroleum based crop protection tools.

Agriculture is part of the existing environment and to ensure that agriculture has room to adapt to a warming climate by moving onto lands in cooler climates further north or in higher altitudes, local general plans will need to zone for and protect such lands for future agricultural growth. Such zoning changes need to be coordinated with design and connectivity of landscape preserves for biodiversity conservation (see Biodiversity and Habitat chapter) and should contain right to farm protections to help ensure agricultural viability. Incorporating climate change model results in general plan updates that recognize the value of these lands will need to be encouraged through strategies that provide information as well as incentives to local governments.

Adaptation Strategies and Actions:

California's agricultural sector plays a large role in the state's economy and culture and is thus vital to sustain. California's family farms and ranches fulfill a key role by providing for one of the fundamental needs of society: a safe, secure, and affordable food supply. Moreover, export commodities produced by California's agriculture sector feed consumers across the nation, and around the globe. This enhances the critical nature of the relationship between food security and the agricultural impacts of climate change. To adapt to the expected changes described earlier in this chapter, the sector has a wide range of options. Those which are consistent with the activities of DOC (Department of Conservation) and CDFA (California Department of Food and Agriculture) include, but are not limited to the following:

Strategy 1 - Water Supply and Conservation Support

Near Term Actions:

a. **Water Conservation** - Continue to enhance water conservation activities at the farm and district level by initiating incentives, distributing information and introducing other strategies that encourage the development of diverse farm and irrigation district water sources.

   i. **California Irrigation Management Information System** - Expand the collection and dissemination of local weather information for irrigation planning and expand the California Irrigation Management Information System (CIMIS).

   ii. **Mobile Irrigation Labs** - Increase support for water stewardship practices either through expanding the role of mobile irrigation labs or through other services provided by Resource Conservation Districts, Water or Irrigation Districts, and Cooperative Extension services.

   iii. **California Agricultural Water Management** - Support expansion and development of voluntary district-level water conservation plans for all agricultural water districts; and encourage the implementation of approved district conservation plan actions (e.g., tailwater return ponds).

   iv. **Collaboration & Partnerships** - DOC will collaborate with the USDA Natural Resources Conservation Service, DWR, CEC, and CDFA to prioritize and expand technical and financial cost-share assistance programs (e.g., water stewardship practices, farm conservation planning, water use efficiency, micro-irrigation, low energy precision application drip systems, and land-leveling) for growers.

   v. **Energy Efficient Water Recycling** - Invest in new uses for saline drainage water, using renewable solar and on-farm bio-fuels energy sources to treat saline water. This is partially mitigation, but should focus on re-use of saline drainage on more salt tolerant crops, or to expand supplies through treatment.

   vi. **Water Incentives** – Incentivize water pricing systems that reward conservation, accounting for regional differences in growing conditions, crops, and other agronomic needs. Create incentives and streamline regulatory requirements for agricultural water users to make more water available for other beneficial uses through voluntary water transfers.

vii. **Urban Conservation Programs** - Invest in urban water conservation programs that result in increased local sources of agricultural irrigation water available for future use.

viii. **Water and Energy use Efficiency on Farms -** DOC shall implement statewide expansion of the Watershed programs which support adaptive management through watershed stewardship and project implementation grant awards, including practices that increase water and energy use efficiency on farms.

ix. **Dry Farming –** Dry farming in higher rainfall coastal regions has traditionally produced high quality crops, such as wine grapes and apples. Through water conservation funding, develop incentives and marketing to support appropriate coastal zone dry farming recognizing that there will be a likely reduction in crop yields and/ or reliability of harvests and in turn available local food supplies.

b. **Floodplain Easements** - Work with willing sellers to identify voluntary floodplain corridor protection (flowage) easements on agricultural lands to maintain agricultural production that is compatible with flood conveyance. These actions will also enhance economic sustainability and protect urban residents from flooding, provide improved shallow water and seasonal wetland habitat, improved fish passage and nursery conditions, while protecting agricultural lands for the continued production of food and fiber.

Long Term Actions:

c. **Drought Tolerant Research** - Support research and development for more drought-tolerant cultivars, crop rotations, and crop mixtures.

d. **Improve Water Reliability** - Initiate reliability of irrigation water delivery to facilitate farm and district-scale crop and farm management to better adapt to climate change.

i. **Water Projects** - Continue to improve the coordination of the State Water Project, Central Valley Project, and Colorado River Project operation.

ii. **Water Conveyance** - Improve state and regional water conveyance systems to move more wet-year flows to off-stream and groundwater storage and to facilitate intra-regional water transfers.

iii. **Increase Storage Capacity** - Expand and improve the use of existing surface and groundwater storage capacity while developing new surface and groundwater storage. On-farm ponds and increased soil moisture storage are additional ways to provide operational flexibility and short term storage capacity.

iv. **Integrated Regional Water Management Planning** - Increase regional reliance of water supplies through continued support for integrated regional water management planning.

v. **Increase Recycled Water Use** - Consistent with state policy, supplement existing agricultural water supplies by encouraging the increased agricultural use of recycled urban water.

e. **Reduce Flood Impacts** - Initiate actions to reduce the harmful effects on agricultural lands from increased flooding likely from more intense storms and sea level rise.

i. **Levee Improvements** - Improve levees to protect the state's most productive farmland and reduce damage to investments, such as agricultural infrastructure and irrigation systems (e.g., land leveling and irrigation ditches, etc).

ii. **Enhance Water Capture** - Promote measures that rainfall capture by improving groundwater infiltration and soil retention/capture.

f. **Develop Severe Drought Response Strategies** – Support research and development of emergency response plans for agriculture in severe drought.

g. **Support research on practices to promote soil water-holding capacity--** California Department of Food and Agriculture, the University of California Cooperative Extension, and other interested entities should continue to support new and existing research on farm management practices that result in increased soil water retention, thus reducing irrigation needs and runoff. Research on these agricultural practices include, but are not limited to, cover cropping, conservation tillage, increasing the use of renewable inputs, increasing the carbon content of agricultural lands, improving soil fertility, and reducing evapotranspiration. These endeavors should be inclusive of conventional, organic, and other food production systems and shall do so with a focus on meeting a growing global food demand.

Strategy 2 – Preventing, Preparing for, and Responding to Agricultural Invaders, Pests, and Diseases

The California Invasive Species Council (CISC) will coordinate invasive species response for the State. The CISC mission is to provide policy level direction and planning for mitigating harmful invasive species infestations throughout the state and for preventing the introduction of others that may be potentially harmful; and to foster coordinated, streamlined approaches that support initiatives for the prevention and control of invasive species, avoiding program duplication by building upon the core competencies of member organizations. The CISC is chaired by Secretary of CDFA and vice-chaired by Secretary of CNRA. Also serving on the council will be Secretary of California's Environmental Protection Agency; Secretary of Business, Transportation and Housing Agency; Secretary of California Health and Human Services Agency; and Secretary of California Emergency Management Agency.

Near Term Actions:

a. **Inspection Stations** – Increase vigilance and develop a long-term funding strategy at the state's port-of-entry inspection stations to prevent entry of new diseases, pests and weeds.

b. **Statewide Detection** - Increase the effectiveness of statewide detection system in order to detect newly introduced pest species.

c. **Risk Analysis of Potential Invasives –** CDFA, UC Cooperative Extension, and CEMA should collaborate in developing risk analysis of foreign plant and animal pests that could invade California, to aid in better preventing introductions and better preparing for emergency eradication responses.

d. **Pollinator Technical and Financial Assistance** - Provide technical and financial assistance and incentives for the conservation of "bee pastures" and the use of on-farm planting beneficial to native and non-native pollinators, all with consideration given to crop compatibility (i.e. seedless crop varieties).

e. **Information Distribution** - Provide information to the agricultural community to enable growers to modify farm management practices and adapt to new pests and diseases.

Long Term Actions:

f. **Prevention and Detection** - Invest in the prevention, detection and eradication of noxious invaders due to climate change that come from outside California, and native California species that move into new regions of California.

    i. **Collaboration and Information Sharing** - Increase interstate and statewide cooperation in the sharing of databases, modeling, detection, warning systems and eradication.

ii. **Field Experiments** - Initiate field experiments for climate gradients that represent the range of future climates (e.g., landscape surveys) providing data on predictors, potential invasions and expansions of pests, weeds and diseases.

iii. **Identify Risks** - Identify pests and pathogens that may potentially place California at risk. Conduct analysis of previously developed scenarios from regions with similar climatic conditions.

g. **Sustained Research and Extension** - Invest in research and development of control strategies and chemicals that add to the toolbox of Integrated Pest Management in anticipation of climate change. Distribute research results through University of California Cooperative Extension programs.

i. **Adaptive Strategies** - Support research into management strategies that assist grower adaptation to increased pest and disease pressures, such as changes in planting, thinning and harvesting timing, planting of crop mixtures, and crop diversification practices.

ii. **Resiliency Development** - Safeguard farm and regional crops and livestock against uncertain pests and disease exposure by developing more resilient cultivars and breeds (i.e., develop more stone fruit varieties with fewer chill hours required for good harvests); develop inter-cropping and soil enhancing practices which improve plant, field, and landscape scale resilience. Develop practices that improve resilience of field and landscape, through research, development, and support of diverse crop and livestock populations.

iii. **Disease and Pest Resistance** – Support research and development on the identification of plant cultivars and livestock breeds that are resistant to predicted disease and pest pressures. Reduce dependence on off-farm inputs through continued research, development, and support of Integrated Pest Management practices.

iv. **Bee Colony Collapse -** Support research on the causes of bee colony collapse and the effects of climate change and adaptation strategies on healthy native and non-native pollinator populations.

v. **Modeling** - Support research on impacts of climate change that improves our understanding through the development of better scientific models on temperature and precipitation patterns to predict the spread of disease, noxious weeds and pests.

Strategy 3 - Land Use Planning Practices

Near Term Actions:

a. **Policy Integration** – CDFA, in collaboration with the Strategic Growth Council and other agencies, should provide guidance for cities and counties to help develop and adopt sustainable agriculture[iii] policies, particularly in conjunction with smart growth planning initiatives.

i. **Protection of Farmland -** Under the leadership of the DOC, ensure the continuation of the Land Conservation Act (1965) and the California Land Conservancy Program, as well as other local and state agency programs to permanently protect farmland. Use the Land

[iii] Per the 1990 "Farm Bill," sustainable agricultural policies consist of an integrated system of plant and animal production practices having a site-specific application that will, over the long term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole.

Conservation Act in combination with the Farmland Mapping and Monitoring Program and the California Farmland Conservancy Program to identify and secure lands that offer future productivity potential against climate impacts (e.g., lacustrine and alluvial soils at higher elevations, or northern climates.)

ii. **Adaptable Farmlands** – Encourage the conservation of the most productive and adaptable farmland by supporting land conservation programs and smart growth (e.g., urban growth boundaries, in-fill, redirection and redevelopment of existing urban areas).

iii. **Community Land Use** – CDFA will encourage community land use planning to support sustainable agriculture at the urban interface, helping to give a level of certainty to growers of the future use of their lands for agriculture.

iv. **Local and Regional Markets** – Encourage and support the development of local and regional markets allowing smaller farms a niche to coexist on smaller parcels in near-urban environments. DOC Farmland Conservancy Program, utilizing data from the DOC Farmland Mapping and Monitoring Program, has developed a prototype foodshed map, starting with San Francisco, in response to the cities' local food initiative. Such foodshed mapping products can facilitate sound regional planning to optimize farmland conservation.

v. **Mapping Collaboration** - Develop and employ methods to update existing soil classification maps based on climate change scenarios in collaboration with the Natural Resources Conservation Service.

b. **Wetland Easements** – Pursuant to DWR Water Plan 2009, continue purchase of wetland easements on marginal, flood-prone, agricultural lands to diversify grower income and buffer productive lands from flood events and improve the environmental services provided by these lands. These efforts may include DWR, DFG, NRCS (Natural Resource Conservation Service), WCB (Wildlife Conservation Board) or other funding sources and incentivize private investment in the establishment and preservation of wetlands.

***Long Term Actions*: -** The near term actions, as they are comprehensive, are expected to continue long term. Additional long term land use actions for consideration include the following:

c. **Farm Carbon Sequestration** - CDFA and the Resources Agency will work with the Climate Action Team and the Air Resources Board to identify opportunities to include farm carbon sequestration as an offset credit. Examples include promotion of offset credits for GHG emissions trading that includes the carbon sequestration by soils and other GHG reduction measures, as well as supporting research and development of protocols for agricultural practices that can potentially reduce GHG emissions. CDFA shall have a major role in developing the mechanisms for offset credits.

i. **Credits and Offsets** - Promote the integration of carbon offset markets with environmental market credits (i.e., water quality and wildlife habitat improvements) to reduce greenhouse gases, and improve the economic and environmental sustainability of agricultural operations.

Strategy 4 – Promote Working Landscapes with Ecosystem Services to Improve Agrobiodiversity

Near Term Actions:

a. **Technical Assistance and Outreach** - Use new and existing technical and financial assistance programs, and informational outreach where appropriate to increase the diversification of the agricultural region from field to landscape scales. For example, inter-cropping with rotations, cover cropping, hedgerows, riparian restoration and wetlands can provide grower opportunities for diversification of income from carbon sequestration and other environmental services credits; create opportunities for pest predator and pollinator habitat; and enhance resilience against climate change.

b. **Bio-Energy** – The University of California Cooperative Extension (UCCE), along with the California Energy Commission (Energy Commission) and the California Department of Food and Agriculture (CDFA) should encourage the development of sustainable agricultural feedstocks for bio-energy that use marginal land and avoid competing with both plant and animal food production.

Long Term Actions:

c. **Climate Adapted Crops and Crop Mixtures** - Support identification, research, development, and breeding of crop varieties, cultivars, and mixes of crops capable of adapting to expected climate change (e.g. with respect to changes in temperature, precipitation, pest and disease resistance, air quality, salt tolerance and drought tolerance) in order to assist growers in the selection of crop and livestock most likely to succeed.

d. **Crop Diversification** – The University of California, in partnership with the Energy Commission and the CDFA should support the identification, agronomic and economic analysis of multiple crop types and second-generation (cellulosic) energy crops for use by growers to diversify their production options, improve their ability to adapt to climate change, and create long-term opportunities for recycled water reuse.

e. **Economic Evaluation of Systems that Enhance Ecosystem Services** – The University of California, in partnership with the Energy Commission, CDFA, and other agencies, should support the identification of new or evolving markets for systems that fulfill consumer demand for reduced “foodprint” agricultural products: methods that enhance, enrich, or regenerate soil; require reduced farm inputs; or reduce energy consumption or feedstock and product transportation needs (including conventional and organic farming); opportunities to fulfill consumer demand for agro-tourism; and other emerging consumer driven markets. Research on agronomic and economic efficiency of these new systems will support their continued adoption and expansion, where appropriate. .

Strategy 5 - Farm and Land Management Initiatives

Near Term Actions:

a. **Permit Streamlining** – The State Environmental Protection Agency (CalEPA) and CDFA will promote and facilitate permit streamlining coordination of dairy digester technologies and other initiatives (regulatory and voluntary) that have a net benefit to food supply, climate change, and the environment. CalEPA, CDFA, and other state agencies should promote technical and financial assistance for regional and on-farm sources of renewable energy and encourage the economic and environmental sustainability of California farms, dairies and rural lands.

Long Term Actions:

b. **Technical Assistance & Funding** - Complement federal financial and technical assistance such as those offered by the NRCS for farmers under the co-leadership of the Department of Conservation (DOC) and the CDFA to collaboratively encourage improved farm management practices involving tillage, rotations, manure management, fallowing, use of cover crops, inter-cropping, multi-cropping, and fertilizer-use efficiency, which result in net environmental benefits including reduction of soil erosion, increased soil fertility, water-holding capacity, and reduced on and off-site contamination of water resources.

c. **Grower Outreach** – State agencies should partner with existing information networks such as UCCE, RCDS, etc to provide information on the benefits of crop management (e.g., manipulation of planting, thinning and harvesting dates, crop mixtures, crop diversification from within-field to landscape scale, etc.) in order to adapt to climate change impacts resulting in the increase of crop pests and disease, as well as increases in temperature and changes in precipitation.

d. **High-Carbon Crop Cultivation** – State agencies should incentivize the use of crop options, encourage economic sustainability and the development of carbon credit protocols for the cultivation of woody plants in appropriate natural areas (e.g., riparian forests, hedgerows and windbreaks.) These endeavors shall be mindful of any potential reduction in food supply.

e. **Research** - State agencies should continue to invest in research and development to determine nitrous oxide generation from soil, irrigation, carbon and nitrogen input from various sources and application methods. Such research should explore relative benefits of organic and inorganic sources of nitrogen, with the aim of reducing the need for off-farm sources of nitrogen. Identify peer-reviewed scientific research that supports industry-wide practices that will reduce greenhouse gases. Develop protocols where appropriate and feasible that provide incentives to growers (e.g., GHG credits) to improve fertilizer and manure delivery technology, or reduce the need for off-farm sources of nitrogen fertilizer inputs.

Strategy 6 – Building and Sustaining Institutional Support

Near and Long Term Actions:

a. **Information Clearinghouse** - Establish information clearinghouse(s) for growers that provide information and guidance on adaptive management of crops and cultivars, air quality, precipitation, pests and diseases, climate change scenarios, annual planning, disease and pest invasions, control strategies, water conservation technology, technical and financial assistance, crop failure insurance and general information pertinent to climate change adaptation.